Observing Solar Wind Charge Exchange from a Coronal Mass Ejection

David Henley

&

Robin Shelton

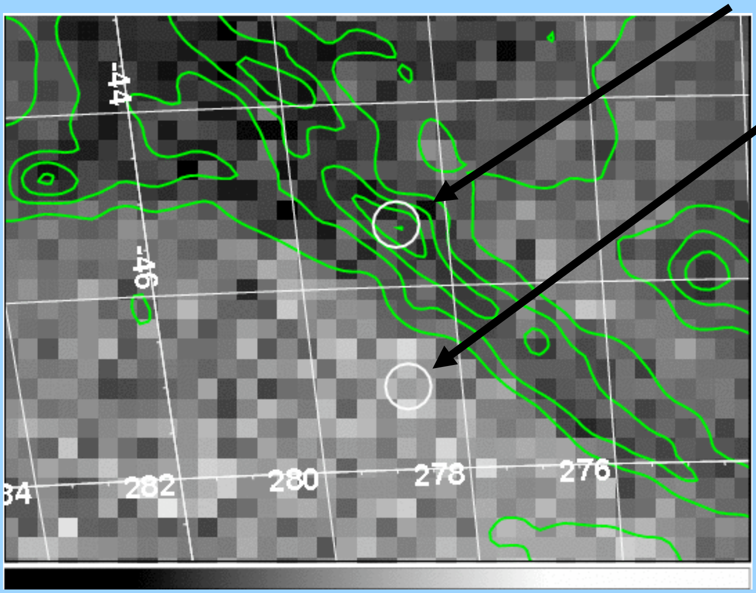
The University of Georgia

Outline

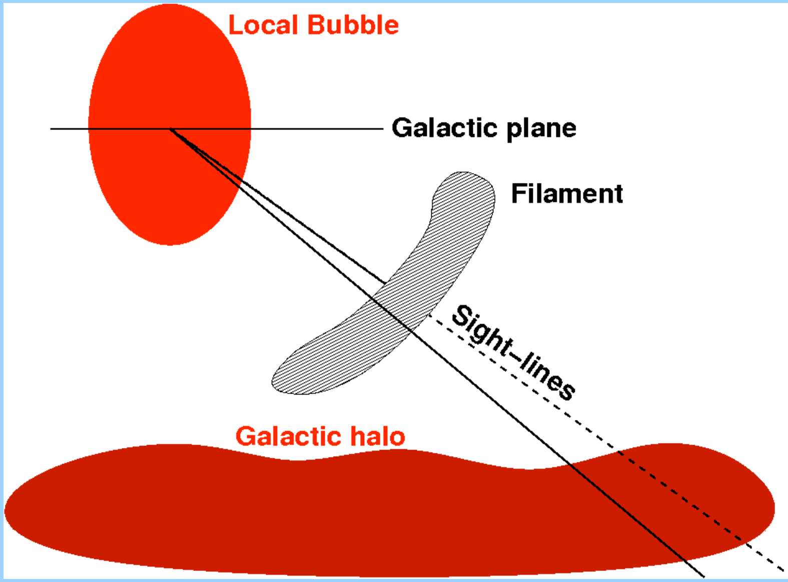
- Shadowing using a nearby absorbing filament
- Comparing *XMM* and *Suzaku* results:
  - *XMM* observations of the filament
  - *Suzaku* observations from the same directions
  - Different results → SWCX emission in the *XMM* spectra
- Comparing observations with heliospheric SWCX models
- SWCX emission from a coronal mass ejection
- Summary

Shadowing Observations of the Soft X-ray Background

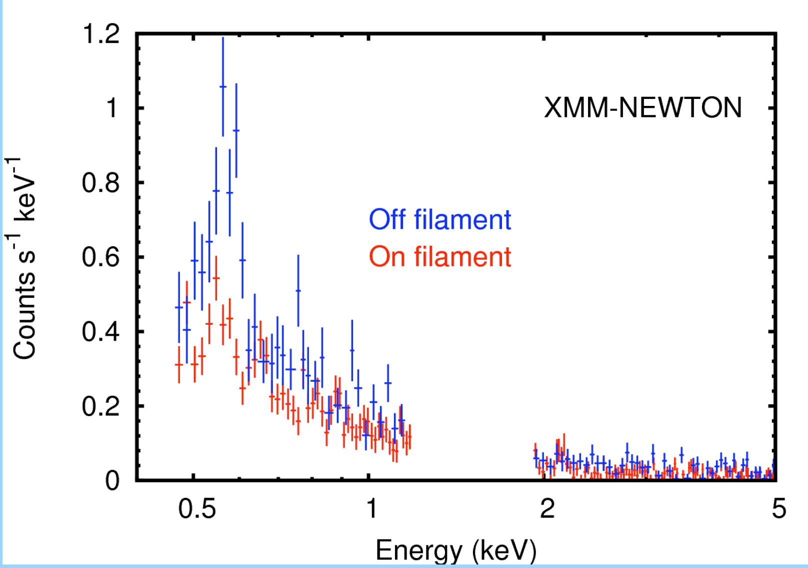
- Original goal: measure spectrum of LB and halo
  - Constrain *kT*, ionization state, abundances
- Use shadowing filament at b ~ –45°
  - *d* = 230 pc
  - *XMM* & *Suzaku* observations on and off filament

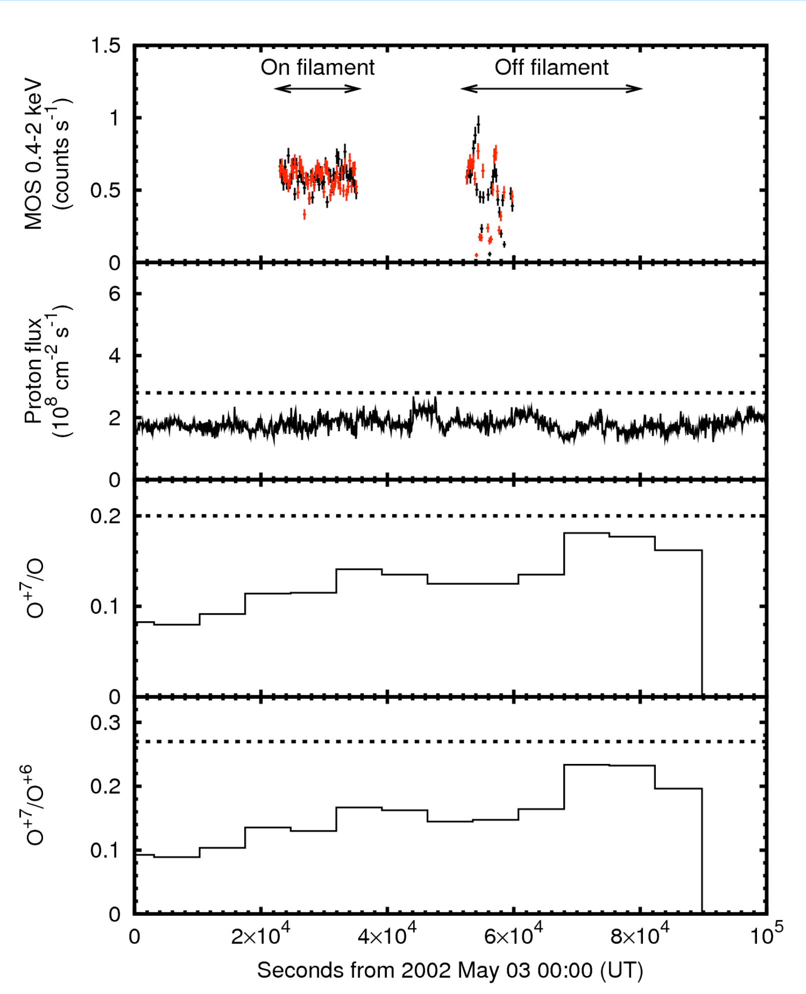


Grayscale: *ROSAT* 1/4 keV
Contours: *IRAS* 100 micron



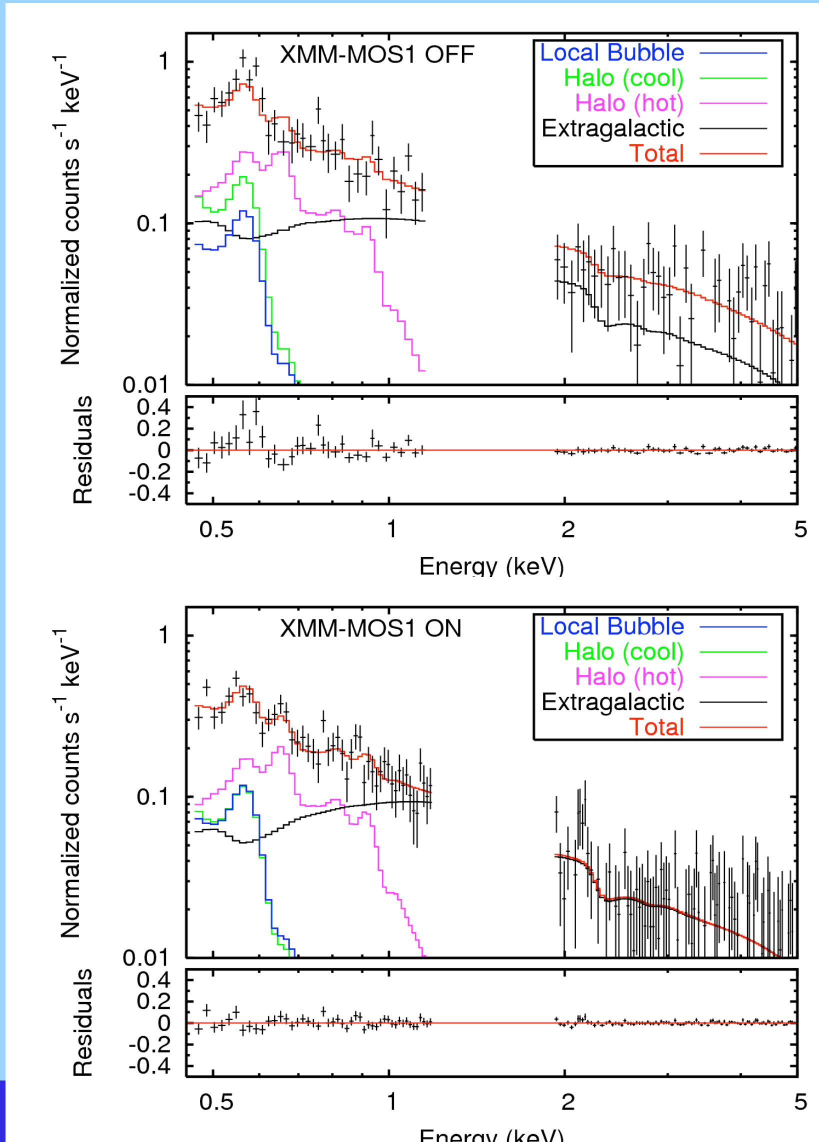
XMM-Newton Spectra
(Henley, Shelton & Kuntz 2007)





- No unusual features in SW data
  - No flares
  - SW data at or below typical values
- Did not expect significant SWCX contamination

XMM-Newton Spectra
(Henley, Shelton & Kuntz 2007)



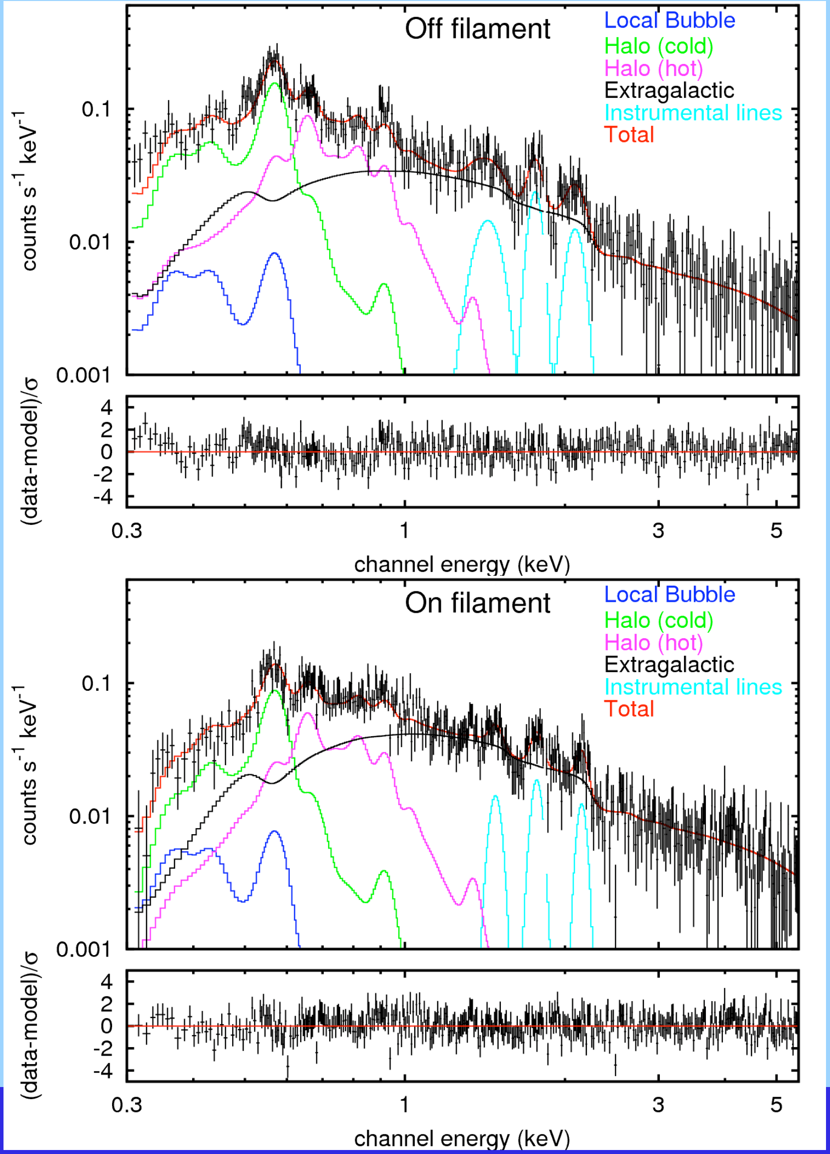
- Spectral model:

  LB + $e^{-\tau}$ (Halo + Extragalactic)
- Include RASS data
- Need 2 halo components

	log T (K)	E.M. (cm^{-6} pc)
LB	6.06	0.018
Halo	5.93	0.17
	6.43	0.011

- Reasonable agreement with previous studies

Suzaku Spectra
(Henley & Shelton 2008)



	log T (K)	E.M. (cm^{-6} pc)
LB	5.98	0.0064
Halo	6.11	0.035
	6.50	0.0065

Compare with *XMM*:

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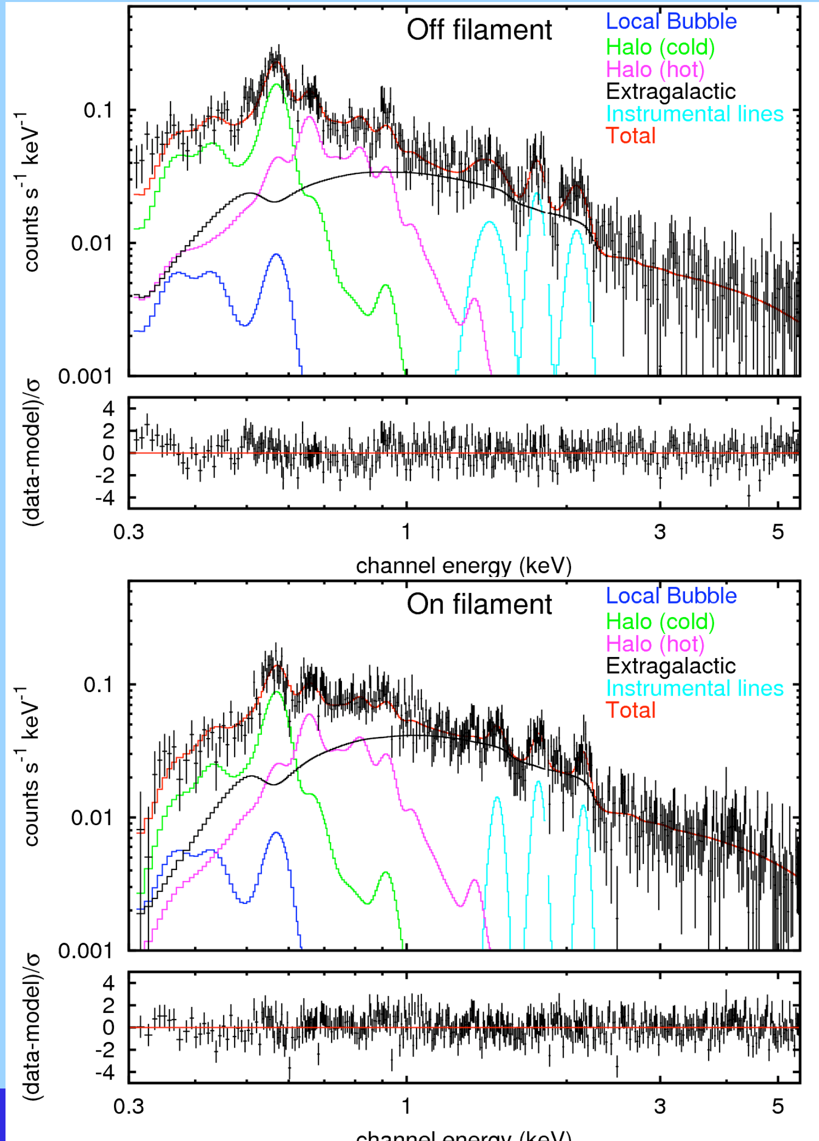
Different codes used:

- *XMM*: APEC for everything
- *Suzaku*: RS for *ROSAT* 1/4 keV

Suzaku Spectra
(Henley & Shelton 2008)



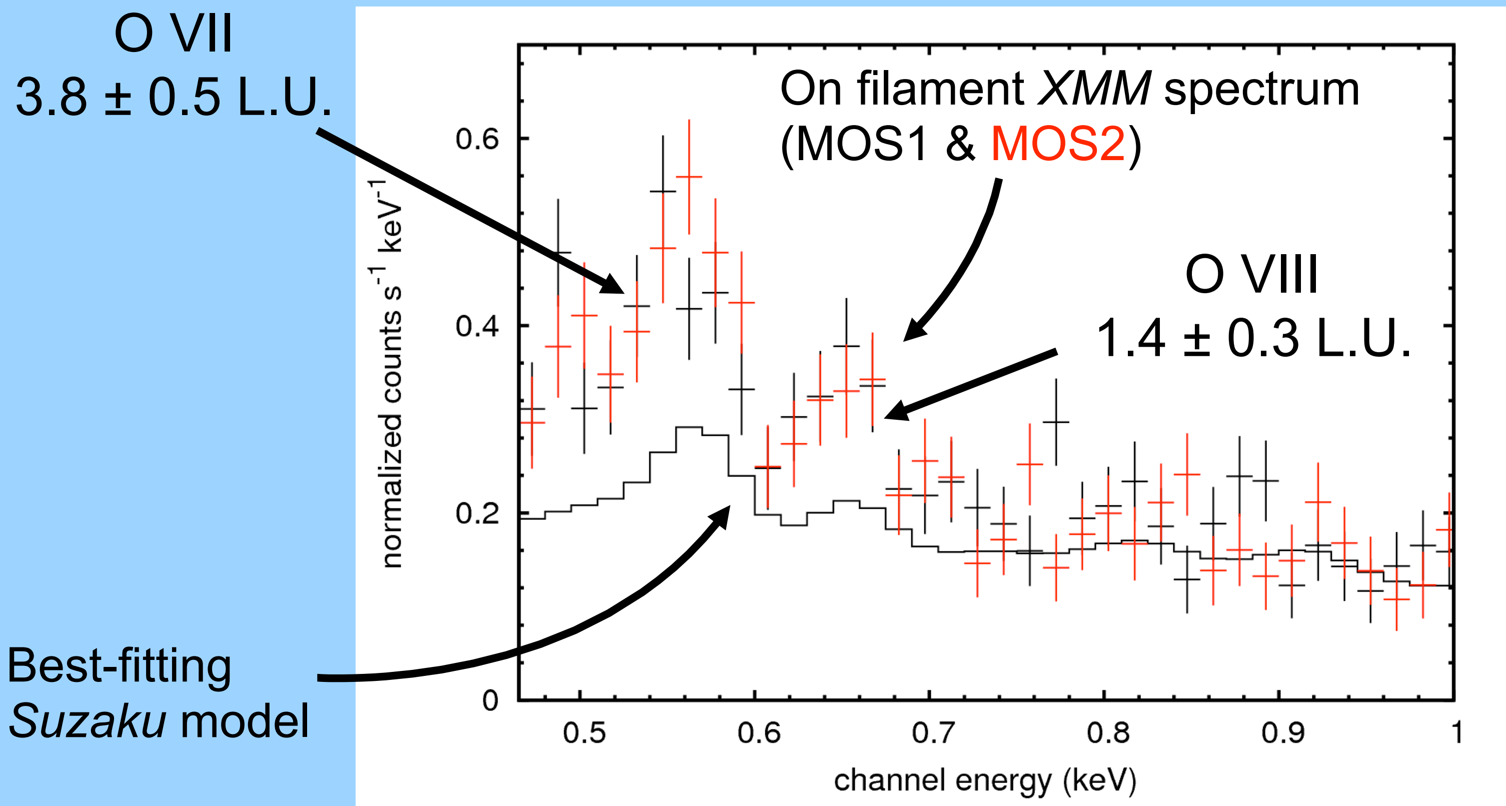
	log *T* (K)	E.M. (cm^{-6} pc)
LB	5.98	0.0064
Halo	6.11	0.035
	6.50	0.0065

Compare with *XMM*:

LB	~~6.06~~	6.30	~~0.018~~	0.013
Halo	~~5.93~~	5.73	~~0.17~~	0.16
	~~6.43~~	6.56	~~0.011~~	0.0038

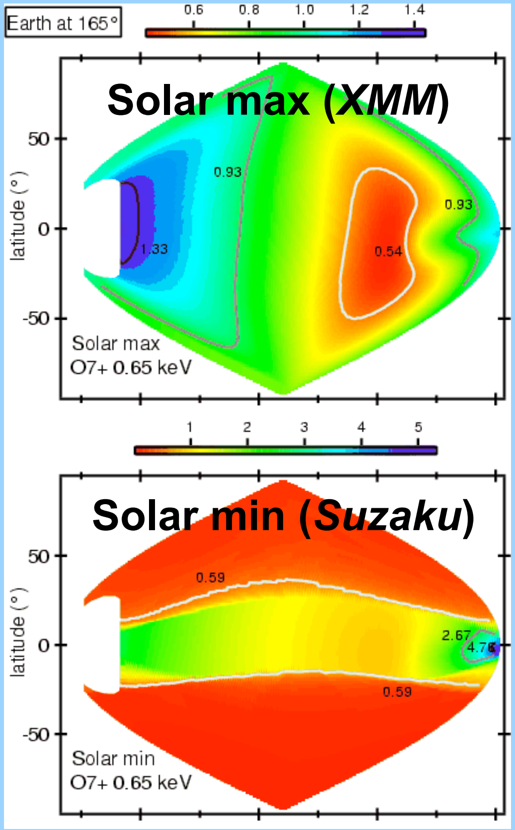
Re-doing the *XMM* analysis does not get rid of the discrepancy

SWCX Emission in *XMM* Spectra



- Extra emission component in *XMM* spectra (in addition to LB, halo, extragalactic background)
  - Solar wind charge exchange emission

Comparing Observations with Heliospheric SWCX Models

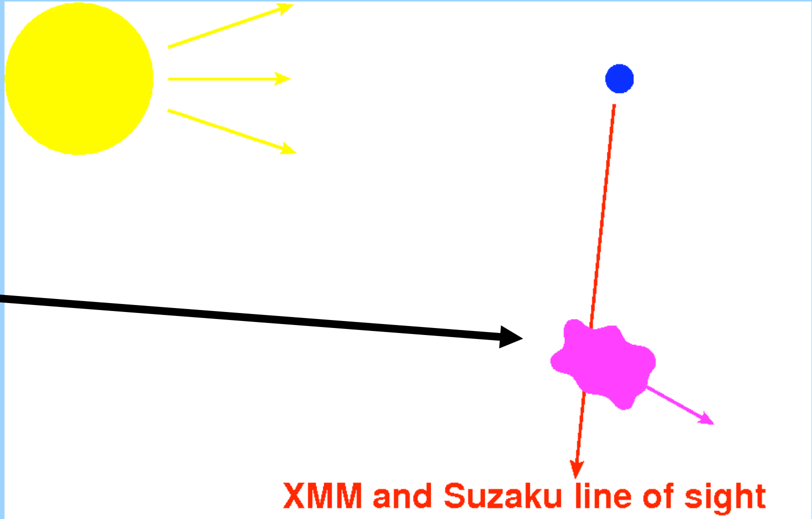


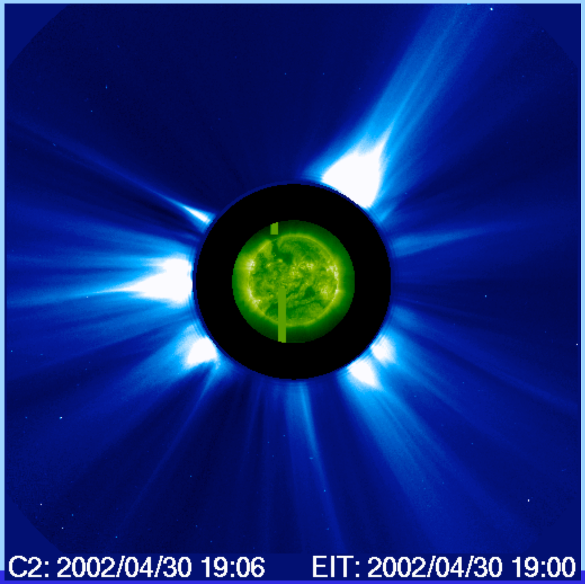
- Koutroumpa et al. model takes into account solar cycle variations
  - More O^{+7}, O^{+8} ions along sight-line at solar max than at solar min
- Model predicts higher O VII & O VIII fluxes for *XMM* (solar max) than *Suzaku* (solar min)
- “Ground level” model underpredicts *XMM* intensities:

	O VII (L.U)	**O VIII** (L.U.)
Observed *XMM* excesses:	3.8 ± 0.5	1.4 ± 0.3
Koutroumpa et al. (2007):	2.32	0.92

SWCX emission from a Coronal Mass Ejection (CME)

- Excesses in *XMM* spectra may be partly due to localized SW enhancement moving across sight-line
- CME emitted ~2.5 days before *XMM* observations (Koutroumpa et al. 2007)





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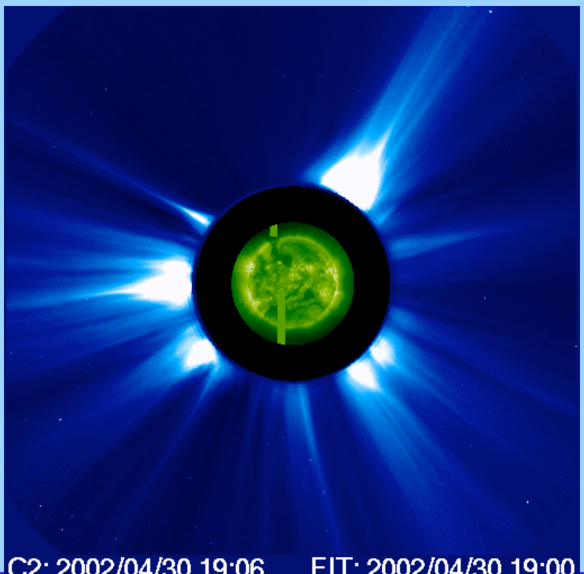
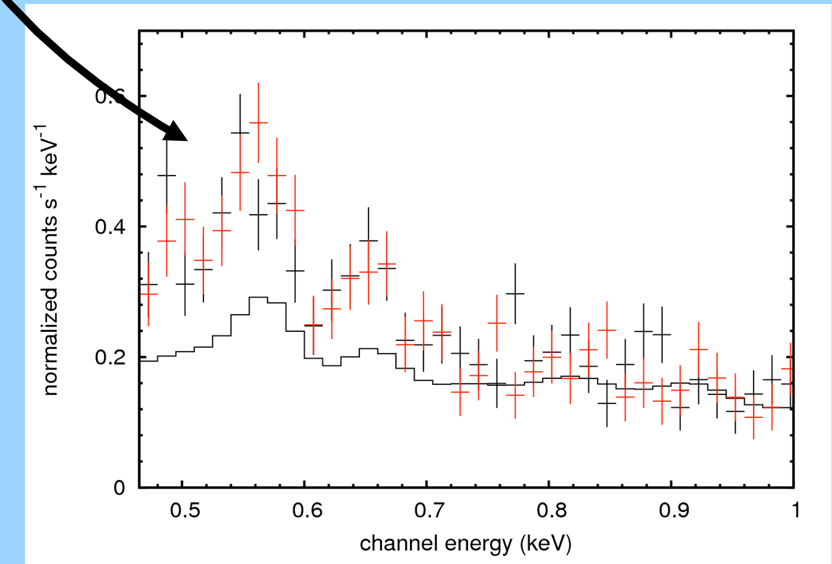


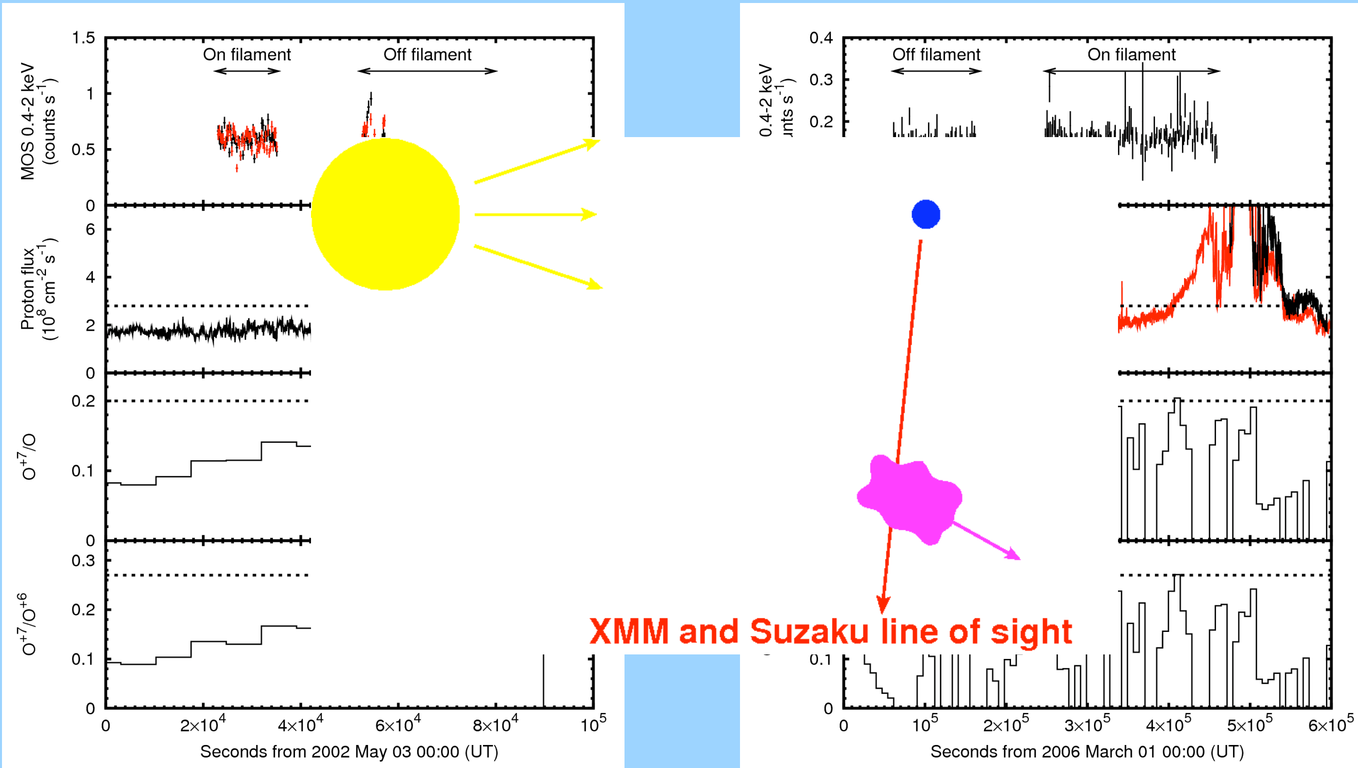
- Differences between *XMM* and *Suzaku* yield SWCX spectrum of a CME
  - Could be used to probe composition of CMEs



Looking for Indications of SWCX in *ACE* Data

XMM

Suzaku



- *ACE* data: no indication that *XMM* spectra were contaminated
- In general, CMEs will not be seen in *ACE* data
- Simply inspecting *ACE* data may be inadequate for determining if SWCX is contaminating a X-ray b/g spectrum

Summary

- *XMM* and *Suzaku* shadowing observations of absorbing filament yielded different results
- *XMM* spectra are contaminated by SWCX emission
  - Emission probably due to CME moving across sight-line
  - Differences between spectra yield SWCX spectrum of a CME
- Contamination not identified in original *XMM* analysis
  - No indication of SWCX contamination from *ACE* data
  - Contamination unapparent till we compared with *Suzaku*
- Inspecting *ACE* data may be inadequate for identifying SWCX contamination
- Multiple observations essential

Reference: Henley & Shelton, 2008, ApJ, 676, 335